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ABSTRACT

A study examined the role diagnosis plays in the process of revision. Seven student writers and seven expert writers were asked to revise a letter, written from one athletic coach to another discussing why women are reluctant to participate in college sports, for a handout recruiting freshman women. In addition to 26 explicitly "planted problems" (including spelling, punctuation, wordiness, and diction), the task implicitly called for changes in voice, genre, rhetorical stance, perceived audience, and style. Data were drawn from concurrent thinking aloud protocols, cued recall on all changes made, and a task given a week later in which the 26 planted problems were presented in a single sentence, and subjects were asked to identify them. Significant differences were found between the novice and expert writers in the areas of (1) recognizing global problems in writing, (2) turning maxims into action, (3) building a representation of complex problems, and (4) solving ill-defined problems. (Protocol excerpts and two case studies are included.) (HTH)

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Diagnosis in Revision: The Experts' Option

L. Flower, L. Carey, and J.R. Hayes

November 1985

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DIAGNOSIS IN REVISION: THE EXPERT'S OPTION

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Carnegie-Mellon University

November, 1985

Certain skills, such as troubleshooting, are often taken to be the prerogative of the expert whether the task is medical diagnosis, debugging a computer program or diagnosing a text that doesn't sound right. Yet not all experts appear to be good at diagnosis—and not all experts appear to rely on it. What is the place of this special process in a problem solver's repertoire, particularly the repertoire of a writer? This study is concerned with the role diagnosis plays in the process of revision.

The Study

This study grows out of research focused on modeling basic cognitive processes in revision. The subjects were given a letter, written from one athletic coach to another discussing why women are reluctant to participate in college sports, and asked to revise it for a handout recruiting freshmen women. In addition to 26 explicitly "planted problems" (including spelling, punctuation, wordiness, and diction), the task implicitly called for changes in voice, genre, rhetorical stance, perceived audience, and style. It was designed to create a realistic task that called for a wide range of rhetorical, stylistic, and rule-governed revisions. Data was drawn from three sources: from concurrent thinking aloud protocols, from cued recall on all the changes made, which was collected immediately after the task, and from a single sentence task given a week later, which presented the 26 "planted problems" out of context in single sentences and asked only for problem recognition not revision. The fourteen subjects included seven student writers and seven expert writers (three professional writer/editors, and four experienced writing instructors).

The Sub-Processes of Revision

We found that the process of revision presents at least three major hurdles to the writer in the form of semi-independent processes (Hayes, Flower, Schriver, Stratman, and Carey, in press). Difficulty with any one could affect the writer's success. As Figure 1 shows, these begin with the process of TASK DEFINITION. For example, the writer may consider whether this task is going to be a mere patch-up job fixing errors or a more significant rewrite? Given a sense of the task, the writer might also select certain criteria or procedures, such as locating main problems first, as appropriate to use. From the outset of this process, the experts and novices we studied gave themselves both different tasks to do and different operating plans for doing them.

The second major step is EVALUATION which depends on three sub-processes of increasing complexity: Reading to Comprehend, Reading to Evaluate, and Reading to Define Problems (see Figure 1). EVALUATION, broadly considered, is not only a

COGNITIVE PROCESSES IN REVISION

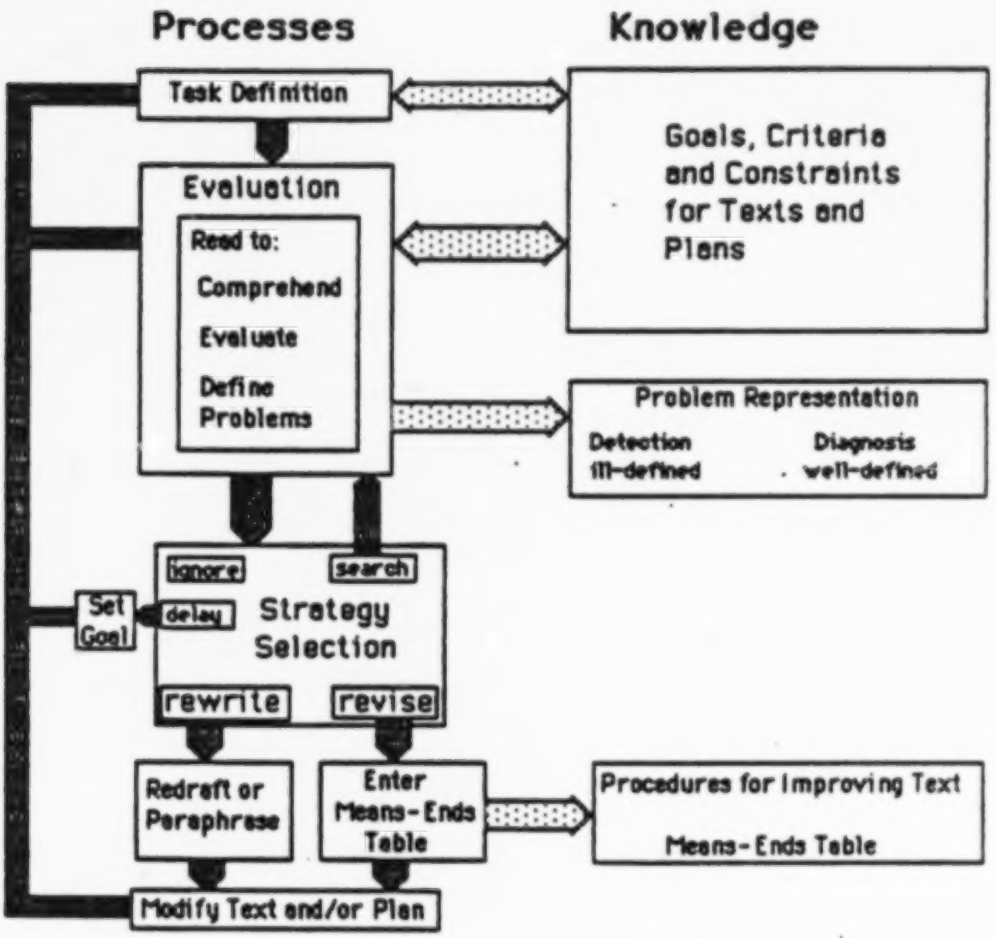

Figure 1 A Process Model of Revision.

process of detecting dissonance but a source of discovery engendered by the mere effort to comprehend. This act of reading and interpretation can trigger associations and new possibilities. As a result, the text may meet the writer's initial criteria (i.e., there is no dissonance between the current reigning intention and text), but this first level of the EVALUATION process may itself suggest an even better plan. The workhorse of EVALUATION, however, is its second sub-process, Reading to Evaluate, in which revisers detect dissonance between their goals-and-criteria and one of the following: a written text, a mental text, or an internal plan. EVALUATION, we argue, operates on all of these entities. The third sub-process that makes up EVALUATION is Reading to Define Problems, in which revisers go beyond the mere detection of problems and dissonance to the diagnosis or definition of those difficulties. EVALUATION then, as we conceived it, can be seen as a process of reading with various goals, which range from the basic goal of comprehending to the more highly constrained intention of not only detecting problems but defining them. This rising level of constraints or demands we place on our reading process is roughly analogous to the difference we feel between reading a paper merely to understand or follow it, versus reading to rate or grade it, versus reading to comment on it or revise.

Whatever the level of constraint at which the reviser is working, the output of EVALUATION is a PROBLEM REPRESENTATION. We observed that the representations people created existed along a continuum from ill-defined representations which contained little information beyond a simple detection (e.g., "this doesn't sound right") to well-defined representations which were high in information that specifically located and defined the problem (e.g., "this should be imply instead of infer"). Most important, from the standpoint of expert /novice differences, was a theoretical distinction we made between **Detection** and **Diagnosis**—the subject of the present paper. Diagnoses, on the upper end of this continuum, represent the problem as a member of a known category, such as "wordy" or "this is going to be insulting to the reader." They differ from Detections, such as "this is terrible," in much the way a patient's heartfelt but weakly specified complaint differs from a physician's more multi-dimensional, high-information diagnosis involving a problem, symptoms, and solutions. The power of diagnosis resides in identifying the situation as a familiar problem type or as part of a schema, which in turn activates a body of tests and solution procedures. Diagnosis also allows strategic revision. Detection, on the other hand, only allows the possibility of rewriting.

We can elaborate this distinction by looking at STRATEGY SELECTION, which is the reviser's third hurdle and the third major process in Figure 1. The writers we studied differed not only in their repertory of **means** for solving problems, but in the dominant strategy they selected. Although our use of the terms **Rewrite** and **Revise** is somewhat arbitrary, it reflects a real distinction. The act of **rewriting** is simply a renewed attempt to meet the current goals—a second pass at text generation trying to say it differently, say it better. (As such, it is no different from the ordinary generate and test procedure we use all the time in trying to hammer out a sentence). **Rewriting** as a do-it-over strategy does not attempt to preserve old text ,and it needs no input other than the fact that the current text "doesn't sound right." The act of **revising**, by contrast, is guided by a **diagnosis** of the problem with the current text. In an effort to conserve surrounding text, revising relies far more heavily on *information available within the problem representation* to guide and focus the writer's effort. Revising, then, is guided and fueled by the writer's diagnosis.

The two major paths we saw writers taking through the revision process are the straightforward path of Detect and Rewrite and the more complex path of Diagnose and Revise (Flower, Hayes, Schriver, Stratman, and Carey, in press). However, among the many expert/novice differences we observed in these protocols, we did not find that experts simply took one path and novices the other. Diagnose and Revise, with its extra cost in attention and requisite knowledge, is only an option—the simpler Detect and Rewrite strategy is frequently the strategy of choice for both groups. Nevertheless, Diagnosis is the *expert's option*—a powerful process the experts chose far more frequently and controlled quite differently than did the novices.

The purpose of this study is to take a look at Diagnosis in action on four somewhat different cognitive tasks. These four sub-tasks are discussed in their order of complexity, and each revealed strategic differences in how the experts and novices we studied used Diagnosis. The four cognitive tasks around which this paper is organized are:

1. Recognizing Global Problems
2. Turning Maxims into Actions
3. Building a Representation of Complex Problems
4. Solving Ill-Defined Problems

The goal of this paper is to build a cumulative portrait of Diagnosis: how it

operates, what skills it appears to require, what sort of representation it produces, and what actions it points toward. Each of the cognitive tasks studied here adds new features to the portrait, but the striking and consistent differences between experts and novices also add up to a coherent picture of what makes Diagnosis a powerful option for the expert. We can sum up those differences best with a metaphor in which we see Diagnosis as a cognitive operation that hands over to the reviser, on demand, a " How-To Manual for the Problem at Hand." This internal "manual" describes the problem and instructs the reviser in what to do.

The diagnostic "manual" which novice writers give themselves has some distinctive features: The problems it covers may reflect global concerns, but are nearly always narrow in their scope. The diagnoses are couched in the language of world knowledge and social interaction. There are many entries on problems typically covered by handbooks and maxims (e.g., wordiness), but these entries seem to contain little how-to or procedural advice for the changing text. Of those procedures that the novice possesses, many appear to have been promoted from the status of a heuristic (such as "don't overuse 'I'") to that of a flat and rigid rule ("never use 'I'"). The section on complex or "ill-defined"problems in the novice's manual is small; it notes only a few, isolated features of such problems. Finally, the novice's instruction manual ends with a practical piece of advice on managing the process: " If the problem you detect is not already covered in this manual, try to solve one that is."

The diagnostic manual the experts construct is different in some telling ways. It contains, as we might expect, many more problems which are broadly conceived in both their concerns and text scope. The set of maxims looks much like the novices', except that each one is followed by list of quite specific how-to procedures for using the maxim. The section on complex problems in the expert manual contains a remarkably detailed "exploded view" of the problem seen as a whole network of connected features. The links in this network go across all four levels of word, sentence, paragraph, and whole text. The expert's representation of such problems is often a "two-page spread" in which features of the problem are elaborated, integrated with one another, and connected to specific locations in the text. Finally, for problems not already covered directly , the expert's manual appears to contain 1) a large repertory of general problem-solving and planning procedures and 2) a few simple but forceful words of advice: "Be persistent; see what you can do."

As this sketch suggests, understanding Diagnosis is worthwhile simply because it is

such a powerful troubleshooting procedure for experts. But beyond that, we hope to show how studying Diagnosis can help us understand two crucial processes which underly cognition in writing more generally: these are the act of *representing problems and goals to oneself*, and the ability to *turn such knowledge into action*. Diagnosis, we believe, is a window on these two cognitive processes that make a large difference in performance.

I. RECOGNIZING GLOBAL PROBLEMS

Let us begin with a familiar question: Do experienced and inexperienced writers deal differently with that class of problems we typically call "global" or "whole-text" problems? In light of previous research (Bridwell, 1980; Faigley & Witte, 1981; Sommers, 1980), the most obvious inference is that novices simply do not diagnose such problems at all. The results we see in the *final products* of novice revision leads us to three reasonable hypotheses about the *writer's process:*

Hypothesis 1: Novices do not diagnose the global problems that affect readers of the text. That is, they are not really aware of or do not consider audience or purpose in their evaluation. Instead, they operate as error finders. Under the influence of handbooks and teachers they concentrate on rule-governed features of the text and rely on textbook maxims or maxims turned into rigid rules even in the face of more complex, ill-defined problems. In essence, they ignore the big picture in favor of correcting local details of the text.

Hypothesis 2: Novices do diagnose and ponder global problems, but are either unable or unwilling to act on that knowledge in revising the text.

Hypothesis 3: Novices are indeed aware of audience and purpose, but they look at such problems through a narrow window. Large issues of audience and purpose are attended to only as they surface in local problems within small units of text, that is, as they effect matters at the word and sentence level. Working only with problems that fit within this narrow window, even writers who attend to the reader are unlikely to make significant additions to content or to change the macrostructure or gist.

Although these hypotheses reflect reasonable inferences, our research suggests that only the third one is true. Let us consider why. A "global" diagnosis or revision

contains two distinct features which are often unwittingly conflated. One aspect of a "global" diagnosis is its scope, that is, the size of the window the reviser looks through and the size of the text unit he or she surveys (as reflected in Hypothesis 3). The other aspect of a "global" diagnosis is its concern with intentionality, that is, the the diagnoser's awareness of broader (more global) issues of audience and purpose (as reflected in Hypotheses 1 and 2). It is possible, then, for a reviser to diagnose problems that are global in one sense (e.g., in scope or intentionality) but not the other.

As Figure 2 shows, the diagnoses our subjects made could be divided into three kinds: those based on **Rules**, those based on **Maxims**, and those based on **Intentions** (that is, on the reviser's sense of this text's purpose or audience). To create an intentional diagnosis the reviser had to compare the text not simply to a known rule or maxim, but to a sense of the intentions behind this text, intentions which the reviser had to infer or construct for himself. Given the results of previous research and the extra difficulty of this operation, we expected these intentional diagnoses to be the special prerogative of experts. True to form, the experts were making global diagnoses in both senses of the term global. They dealt with units well beyond the scope of word and sentence and they were actively evaluating the text in light of underlying intentions. However, the percentage of diagnoses which could be classed as intentional diagnoses was no higher for experts than for novices. At this level of the revising process, students and their teachers looked surprisingly alike.

In understanding why novice revisers appear to ignore global concerns, Hypothesis 1 proved to be surprisingly wrong. Our novices made a great many diagnoses based on audience and purpose -- on how a reader would react and what they thought the text should achieve. Awareness of a reader did not appear to be the mising link in these students' performance. They showed an active awareness of what readers might think and say in response to the text and attacked such problems with vigor, as in the following intentional diagnosis: The original text tried to make sports attractive by saying, "Therefore, many of the teams are less competitive than many students expect." One student diplomatically altered the "are" to "may be" saying, "Well, some students like competition and others don't, and that's a nice central standpoint."

(The reader should note here that because this study used a prepared text, we can not say how much this process would change when applied to the writer's own text. For instance, this awareness of the reader would probably diminish in both groups if

Problem Representation Continuum

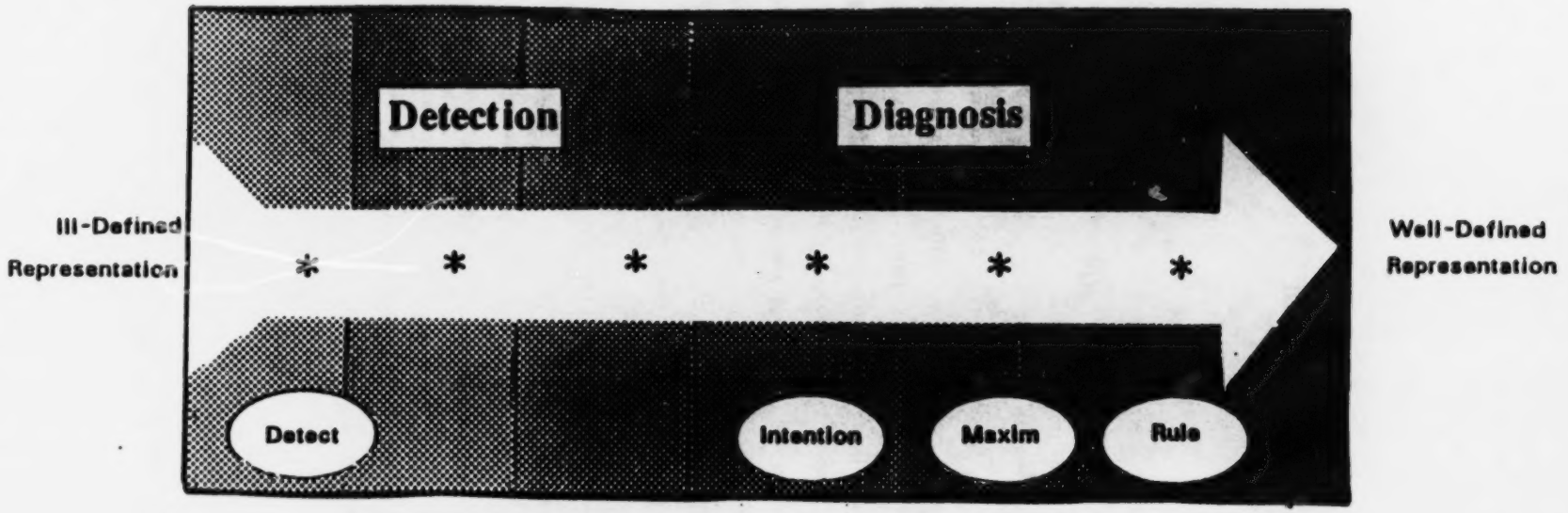

Figure 2. Problem Representation Continuum.

they were asked to review a fresh draft of their own, because the evaluative process of reading to comprehend (which can detect many confusions) would be quickly short circuited. The difference between revising one's own and other's writing (or between revising fresh and cold drafts) is an important one. Our working hypotheses is that ownership and the freshness or familiarity of the text will make some parts of revising much harder (e.g., detecting inferential leaps) and some parts easier. But it is reasonable to think that certain basic cognitive processes, such as detecting and diagnosing, underly any sort of revising, but that writers will adapt those processes to changes in the task. We would also predict—though with less certainty—that the pattern of strategic choices that distinguish expert from novice in this study would be apparent under other conditions as well.)

In this study then, the limiting factor in the performance of the novices was that their broadly intentional concerns were themselves concentrated on problems at the level of a single word, phrase or sentence—problems of narrow scope. Although the protocols revealed sophisticated analyses of readers and of the effects of diction and tone, the scope of all this effort was bounded by the period. As a result, whole categories of problems, including organization, focus and development, were seldom considered by the novices because such problems are not apparent when one's unit of analysis is the single sentence. For example, the experts[1] diagnosed an average of 18.5 coherence problems to the novices' 5.33, and the experts diagnosed problems involving two or more sentences an average of 23.75 times to the novices' 1.5. Thus, this study did not support Hypothesis 1 or 2 which would have the student either blithely unaware of intentional aspects of texts or acutely aware of global problems, but unable to act. It suggested instead that the students we observed were operating with a functionally limited procedure that circumscribed the problems they might consider.

These results imply that changes in the written product are an uncertain guide to the writer's mental process and abilities. Research based on textual evidence has repeatedly concluded that students do not deal with global problems because in textual studies, global is necessarily defined as scope (i.e., as a text unit above the level of the word or sentence.) We have gone on to assume that the other, intentional dimension of global concern was equally absent. Because all the observable changes were concentrated on locally defined problems and small units of text, it was easy to assume that the writer's underlying process was equally limited. And it would be easy to conclude that the revisions would improve if the student

were somehow motivated to consider the audience. Yet when global revision is defined in terms of both scope and intentionality, we find novices carrying out an active but hidden process.

A closer, qualitative look at these diagnoses reveals another difference in the expert response to global problems, which was in the *language of diagnosis*. Although one might predict that these experts ,who included English teachers, would rely on relatively technical terms (such as persona, preview, focus, wordy, and terms from grammar and stylistics), we found no significance difference between experts and novices. In general, no one relied heavily on official terms of art during the process of revision. The difference appears to be a more general and fundamental one. The language of experts is language about texts and about rhetorical purposes. The language of novices is the language of social interaction and human response. The novices then are drawing heavily on their world knowledge about how the reader would respond to being called "naive" or being given irrelevant information. One could say they acted as if they were aware of the Grician maxims for discourse (e.g., be informative, relevant, true and clear; cf. Beach, 1976)—at least as these maxims apply to discourse at the sentence level. The problem with a diagnosis couched in the language of social interaction is that it carries little procedural knowledge about how to fix the text. A diagnosis based on social knowledge doesn't tell you how to turn your social sense into rhetorical moves or textual conventions (cf. Bizzell, 1982). The one thing it can suggest is deletion—which is the most widely observed student revision strategy. In our study deletion was not only invoked to remove offending material, it was also used when the reviser encountered text he or she didn't understand. As we shall see later, the novices consistently attempted to reduce the situation to a manageable problem.

The experts also used the language of social interaction, but for them it was often only a starting point. Intentional diagnoses (i.e. those based on a sense of audience and purpose) exist on the same spectrum from ill- to well-defined that we see in diagnoses in general, as Figure 2 shows. Many complex problems are necessarily ill-defined at first and appear to be best captured by comments which simply simulate a reader's response. For example, upon reading a concluding paragraph urging students to sign up for sports, one reviser responded with a sort of parody of the text—a response that was in effect an interpretation of what the text really conveyed:

> But I wouldn't just leave it—drop by the jail anytime and I'll be happy to tell you...

Although the problem as represented in this comment is certainly an ill-defined one, the comment meets our criteria for a bona fide diagnosis: It places the problem in a category of familiar problems (the uninviting invitation) which in turn points toward possible solution procedures.

Both experts and novices used these simulations of a reader's response and the language of social interaction to diagnose problems; the difference lay in what they did next. In the terms of our model (Figure 1) the action the experts chose was search, which lead them back to their PROBLEM REPRESENTATION in an attempt to re-represent these intuitions as a more well-defined problem. In the example above, the expert followed his simulation with a series of more operational diagnoses and plans:

> I'd make it very concrete, say, call so and so or—or you're going to have this orientation.

The experts often kept working and thinking, pushing their diagnosis further to the right, translating their sense of a reader's response into a representation of *textual and rhetorical problems* upon which they could act. The language of social interaction gave way to the language of rhetorical plans. The novices typically remained with the ill-defined problem with which they started.

To sum up, our students displayed a level of intentionality and audience awareness which the literature would not lead one to expect, Yet this attention to global concerns was constantly limited by the narrow scope of their inquiry and by their dependence on the language of social interaction—a language which fails to translate the problem into observable textual features and rhetorical moves. Responding to global problems in a written text appears to require more that audience awareness and good sense.

These differences between what we might have expected (Hypotheses 1 and 2) and what the writers actually did suggest a need for caution in assuming that we know what students do or don't do when they fail to produce adequate revisions. It is sometimes risky to infer the process and content of a writer's thought from the final product. Revision presents a series of hurdles, any one one of which may govern the changes we see on the page. As a result, instruction may miss the mark by failing to teach those thinking procedures the writer really needs. For example, teachers often try to encourage more global revision by motivating their students to "think about their audience." Yet if the student quite reasonably incorporates this

new concern into the procedure we have just described, all his effort may have little observable effect. The student's "standard operating procedure"—which is to apply world knowledge (now involving the audience) to local problems of diction and content—remains unaltered. In a case such as this we need to understand the inner logic of the novice strategy—to see how that revision process is already working— in order to teach the knowledge or new procedure that will make a difference.

Attending to global problems in the expert sense may call for a set of thinking processes the novice doesn't normally use or hasn't learned. Such procedural knowledge is even harder to acquire in revision than, say, in invention, because the text dictates when to call up that procedure. Revision procedures need to be learned as part of cue/action schemas in which revisers can recognize the cues that call for a given strategy. Consider the case of revising for unfocused paragraphs—a perennial task in revising first drafts. The cues that are the tip off to an unfocused paragraph are not located in individual words or even sentences. They are likely to arise out of dissonance between those sentences and the writer's sense of the gist of purpose of the paragraph. Yet as Witte (1983) has shown, the prerequisite process of reading for gist may not be a part of what inexperienced writers normally do.

To teach writers how to rise to global revisions we need a clearer sense of the intellectual process we are asking for and a more adequate, qualitative understanding of what inexperienced writers are already doing. A part of this picture becomes clearer when we look at what should be an easy task, at how writers use maxims to diagnose and revise.

II. TURNING MAXIMS INTO ACTIONS

As Figure 2 shows, we found that diagnoses varied along a continuum from ill to well-defined, based in part on the nature of individual text problems. Diagnoses which fit on the more well-defined (right hand) end of this continuum were common. For example, in diagnosing stylistic and formatting problems, our subjects frequently drew on well-defined problem categories based on typical handbook maxims such as those suggested by Strunk and White (1979) — i.e. "omit needless words" (p23), "express coordinate ideas in similar form" (p26), "avoid fancy words" (p76), "put statements in positive form" (p19). Unlike rules (e.g. for grammar, spelling or punctuation problems) which are applied unconditionally, maxims provide more

flexible *guidelines* for dealing with common stylistic problems.

Although these "maxim-based" diagnoses were sometimes global in *scope* — i.e. they covered text units of more than one sentence — we cannot consider them global in *intentionality*. Diagnoses of maxim-violations draw on ready-made problem categories. In contrast to diagnoses of the more ill-defined problems of audience and purpose, a reviser does not need to develop her own problem categories based on a reconstruction of the intentions of the current text. Neither does she need to engage in the complex search and planning necessary to successfully solve ill-defined problems; "standard" maxims seem to imply standard and relatively simple solution procedures. We would, then, anticipate that both expert and novice revisers would find maxims relatively easy to apply to problematic text. Certainly, we would expect fewer expert/novice differences in solution procedures than for the more difficult intentional diagnoses.

Yet these assumptions present too simplistic a picture. First, we found some quantitative differences between experts and novices. While both our expert and novice subjects diagnosed stylistic and formatting problems in terms of these common maxims, the novices had a higher overall percentage of maxims than the experts. (Overall percentage of maxim-based diagnoses out of total diagnoses: experts = 16.9%; novices = 30.8%, significant at .02 level by the Mann-Whitney test). We were not too surprised to find that the novices relied more heavily on maxims than the experts. Clearly, one would expect student revisers to look for the problems they have been taught to recognize; conversely one would expect experts to be a little more cautious in their maxim use simply because they are aware of more complexities in the text.

Second, we found some important *qualitative* differences in three areas, which we will examine in detail:

- the procedural knowledge revisers brought to the solutions of maxim-violations
- the complexity and specificity of their problem representations
- the sophistication of their "personal" maxims (ie. maxims that an individual writer develops through his own experience, not necessarily based on standard problem categories)

Given the standardized nature of handbook maxims, these qualitative differences are somewhat surprising. It seems that all maxims may not be created equal for all

writers. Perhaps maxims are not as easy to use as we often suppose when we teach them in composition classes? Certainly, teachers assume that maxims will help students to: 1) recognize and diagnose stylistic problems accurately; 2) apply easily learned solution procedures, analogous to those for fixing punctuation and spelling. For example, teachers may assume that a short-hand version of Strunk and White's maxims such as "express co-ordinate ideas in similar form" will be sufficient for students both to recognize *and* to solve a parallelism problem.

Can students apply their knowledge of standard problem categories to revising a text? Some recent research on the effectiveness of these typical maxim-based teacher comments has drawn into question their usefulness. For example, Sunde (1983) found that students preferred and were better able to use comments which not only gave the problem category, but which also explicitly suggested some solution procedures. In a pilot study which investigated whether students could use problem categories to help them improve a text, Carey and MacNealy (1983) found that maxims did not necessarily translate into actions to improve the text. In this study, the authors gave three groups of students a paragraph containing wordiness, negative structure and lack of parallelism to revise; one group received the text with problems underlined; one group received additional information in the form of common maxims such as wordiness; the third group also received explanations of the meaning of these maxims. They found no significant difference in the quality of the revisions of the three groups. From these results, it would seem that although students may be familiar with the problem category in a maxim, they still have difficulty in applying procedures for improving the text. While they may not lack declarative knowledge about problems, they seem to lack procedural knowledge for fixing them.

Procedural Knowledge

The possible difficulty of translating knowledge about problem types into revision procedures reflects a larger question which applies to many tasks. Are novice problem-solvers able to translate declarative knowledge about a problem into procedural knowledge for effectively solving that problem? Anderson (1980) suggests that this translation may not be as simple as one might suppose. He distinguishes three stages in the acquisition of procedural knowledge: a *cognitive* stage where the novice learns a description of the procedure; an *associative* stage where she can apply this procedure with increasing efficiency but still with deliberate thought; an *autonomous* stage where the procedure becomes increasingly more automatic. For acquisition of physical skills, such as driving a car, a novice goes through all three

stages to become an expert; for more complex mental tasks such as writing and revision she needs at least to move to the associative stage. In assuming that telling a novice how to solve problems of wordy style or non-parallel structure will result in improvements to the text, we may well be assuming that the novice can move to this associative stage without any further help.

Our research suggests that this transition may not be an easy one for many students. While our experts could readily use maxims to help them improve the text, the novices often appeared to lack procedural knowledge for translating a maxim into action. A possible explanation for this difficulty lies in the nature of the procedures associated with maxims. As Figure 2 shows, rules carry clearly specified actions for fixing the text; however, maxims only provide *heuristic* procedures which facilitate but do not exactly specify text changes. In the hands of an expert reviser, these heuristics direct search and planning to specific text features and greatly facilitate changes in, for example, style or format. In the hands of the novice, the heuristics may be insufficiently developed to be of much help when the reviser is faced with problematic text.

We found that our experts often had very well-developed and specific heuristics for translating maxim-based diagnoses into text changes. Let us compare the procedural knowledge of an expert and a novice diagnosing that a list of the benefits of sport did not have parallel structure. The expert commented:

"my first tendency whenever I'm setting up a list is to use infinitives"

Here his procedure for solving the problem is clear — construct a new list of infinitives which captures the ideas in the original text. Conversely, we found that the novices were often unable to draw on such specific heuristics to help them act on a diagnosis. For example, one novice dealt with this same parallelism problem as follows:

"Well, they've got co-operation. It's got to be "tion" and stuff to fit"

She has diagnosed the same problem as the expert using the same maxim, but her procedural knowledge is much less specific; she knows that the words in the list should sound the same but does not know exactly how to achieve the effect she wants. Consequently instead of immediately re-structuring her list, she was forced to try out several different versions of new text until she hit on one which "fit". Another novice was obviously unable to apply her diagnostic knowledge about parallelism to this particular problem. In the Single Sentence task she was able to come up with the following rather vague categorization of the problem.

> "I mean, you have a present tense verb and then you have an explanation of ...a word explaining what they learn...It doesn't seem to me, maybe because of the way co-operation, punctuality, responsibility fit in with interact. It doesn't seem like a full sentence, even though it is. It does have its subject and its verb..."

When confronted with the problem in the actual text, she was unable to operationalize this vague diagnosis; devoid of procedures for solving the problem, she was forced to resort to the trial and error strategy of simply re-writing the text until it sounded better. After fifteen attempts, she finally came up with a version of the text which eliminated the parallelism problem, but also destroyed the logic of the sentence. Without any clear heuristics, her diagnostic knowledge was of little use to her for actually improving the text.

Complex Representation

What would account for the novices' apparent inability to translate maxims into actions? We found two important differences in the nature of experts' and novices' diagnoses based on apparently simple maxims. The experts' maxims typically included 1) a complex representation of different facets of a maxim violation; 2) reference to specific features of the text which were causing the problems. For example, one of the experts saw several nammable dimensions to the wordiness problems which he could apply to specific text features:

- get rid of adverbs
- cut out adjectives
- replace clauses with infinitive phrases
- remove intensifiers such as "even"
- get rid of nominalizations by changing phrases such as "possess the assumption" to assume.

Notice how, under the umbrella of "wordiness", the expert is able to pinpoint features in the text which are contributing to the problem; his diagnosis is operational in that he knows where in the text he needs to focus his attention to eliminate the problems.

In contrast, the novices' maxims appeared one-dimensional, often simplistic and not tied so closely to the text. For example, the following comments typify the novices' use of a maxim to "avoid unnecessary words"

- "I did not think it was necessary"

- "I didn't think I needed that. I just wanted to make a point"
- "There were too many words"

These novices were left with a strategy of deletion, but as their comments above illustrate, their vague diagnoses did not suggest *which* words were in fact unnecessary. The novices above could recognize a standard category of faults, yet they had difficulty locating the source of the problem more specifically in the text. They lacked heuristics to help them to decide which text features were causing the wordiness problems and thus which to delete or re-word.

Not only were the experts' maxims more complicated and text-oriented than the novices', they also embodied more sophisticated rhetorical knowledge about text problems. Such knowledge was not necessarily reflected by a use of specialist technical terminology — in fact, rather surprisingly, we did not often find experts talking in the jargon of the traditional English teacher — but rather in the complexity of the concepts they applied in their diagnoses. For example, novices typically diagnosed the parallelism problems only in terms of grammatical structure, whereas some of the experts also dealt with a more difficult problem — parallelism of ideas as well as structure.

Personal Maxims

We found that many of the experts had created "personal" maxims — that is they had developed their own guidelines (as a supplement to those suggested in the handbooks) for problems they encountered frequently or had a special bias about. We categorized these diagnoses as personal maxims when subjects reported that they *always* dealt with a particular stylistic problem in a similar way; they did not consider the maxim as merely one possible option, but as a standard way of dealing with the problem.

These personal maxims covered a diverse set of problems and of possible strategies for solving the problems, including: sentence structure (e.g. get rid of "there are" constructions; avoid double dependent and subordinate clauses at the beginning of a sentence; avoid participles because they are hard to read); clarity of information (e.g. don't write at a too high level of abstraction; don't over-qualify; don't use double-negative constructions); formatting/genre (e.g. keep a handout to one page; explain abbreviations before using them). For all these problems the experts appeared to have pre-packaged bodies of knowledge which they could apply to any

problematic text, but which were, at the same time, conditional guidelines.

In contrast, we found that when the novices set up personal maxims, they usually were attempting to translate conditional guidelines learned in composition classes into unconditional rules which they applied at best idiosyncratically and at worst erroneously to text problems. As Anderson (1980) points out, once novices have mastered a particular procedure, they are likely to *over-generalize* that procedure and apply it in all contexts regardless of its usefulness; they may lack the ability to discriminate between appropriate and inappropriate use of a particular heuristic. We found several of our novices over-generalizing their personal maxims. For example, one novice claimed

> "I remember using 'however' at the beginning of a sentence in a freshman writing class and getting cut down by the class. So I don't begin sentences with 'however'"

Another claimed that she never began a sentence with "and" for similar reasons; another, that she always used "such as" instead of "like". Although these personal maxims, are more specific than the novices' definitions of, for example, "wordiness", they are focused on trivial, and sometimes erroneous problem definitions. By treating conditional maxims as rigid rules — the same strategy that Rose (1980) observed operating in invention — the novices were looking for simple answers to more complex rhetorical problems; they seemed to lack other more flexible expert options, i.e., heuristics or stored plans, for dealing with stylistic problems.

As we have seen, for the expert reviser maxims provide powerful tools, bringing into play

- well-developed heuristics for making text changes.
- complex, multi-dimensional representations of stylistic problems.
- reference to specific features of the text which are causing the problems
- sophisticated knowledge of rhetorical concepts
- personal variations of standard maxims encompassing a wide range of problem categories and of strategies.

For the novice, however, the maxims we teach may say less than we know. Even though they are one of the valuable staples of teaching, standard maxims do not appear to fully translate knowledge about text problems into specific solutions. A novice who does not have the appropriate heuristics to "bridge the gap" between

declarative and procedural knowledge may be unlikely to improve the text. Maxims may only provide some novices with a vague or simplistic definition of the problem which is not adequately linked to specific text features. Further, novices' attempts to adapt standard maxims into personal guidelines may result in a rigid rule-governed approach to problems rather than a more flexible heuristic search for possible solutions. While teaching students to apply maxim-based diagnoses to poorly written text clearly helps them to recognize problems, our data suggests that we cannot always assume that students will be able to solve the problems they find. Let us now look at how diagnosis operates in a somewhat larger arena -- in the process of representing more complex global problems.

III. BUILDING A REPRESENTATION OF COMPLEX PROBLEMS

The picture of expert diagnosis that emerges from our study of maxims is a series of relatively explicit, articulate comments that create a relatively operational, though non-technical, definition of stylistic problems. How does this fit with an image of the expert doing something as nebulous as "re-seeing" a text or making "whole-text" diagnoses -- actions which would seem to entail a highly abstract, hard-to-articulate vision of the text?

One hypothesis would be that an expert may indeed hold such a gestalt-like mental image of the text and its problems based on a abstract representation of gist or genre schemas (Flower and Hayes, 1984). It seems likely that the protocol data would contain only traces of or oblique references to these packages of knowledge. Supporting this hypothesis and describing this sort of diagnosis would require substantial inferences from the data. We do not want to eliminate this hypothesis, but this study can not adequately support it.

Our data does, however, allow us to explore some other hypotheses about why expert and novice revisers appear to represent these global problems in such qualitatively different ways:

1. Experts build an integrated, hierarchically organized network of diagnoses to deal with global text problems. They notice connections between independent problems at all levels of the text: they see individual choices of diction, style and content in terms of a larger multi-sentence context; they see concrete evidence of broad global problems in smaller problems. Conversely, novices see local disconnected problems which are not tied to the larger context; they either do not see the larger problems, or do not

connect global problems to local ones.

2. Experts build multi-facet, elaborated representations of text problems, rich in information about possible solution procedures; novices build more simple representations which do not allow them either to explore the complexities of global problems or to come up with solutions which adequately solve these problems. Because experts locate these different facets of a complex problem in specific text features, they have a wider base of procedural knowledge to help them solve both individual local problems *and* larger global ones.

To further explore these hypotheses, we analyzed our subjects' diagnostic comments about the following paragraph of our text:

> I don't want to infer that the only chance women get for participating in sports is on varsity teams. Intra-mural sports are not the same as varsity sports in which the rules are better, equipment is better, with the techniques of the players being more developed. Irregardless, IM sports may be the choice for many women — they can be just as much fun and take less time.

We chose this particular paragraph because it contained several fairly local problems such as faulty topic focus, negative tone and structure, faulty parallelism and wordiness; in addition, the paragraph was part of a larger, whole-text coherence problem.

Building an integrated problem representation

Figure 3 shows all the diagnostic comments made by one of our teaching experts about this paragraph; figure 4 shows all those made by a novice. For each subject, we distinguished:

- The text level to which the comment applied — i.e. whole-text / multi-paragraph, paragraph/inter-sentence, sentence, word level.
- The diagnostic "theme" or general category of problem mentioned in the comment.

We looked specifically at whether the revisers built integrated networks of diagnoses which related themes and spanned text levels. Where the subjects made explicit connections between themes, either at the same text level or across text levels, the lines on the charts indicate these connections. Although we found interesting individual differences between our subject groups, these two examples typify the differences in the amount of integration among themes and across text levels in our experts' and our novices' problem representations.

Let us take a closer look at our expert's diagnoses in Figure 3 In order to build a representation of the major problems with this paragraph, the expert (BA) relates her

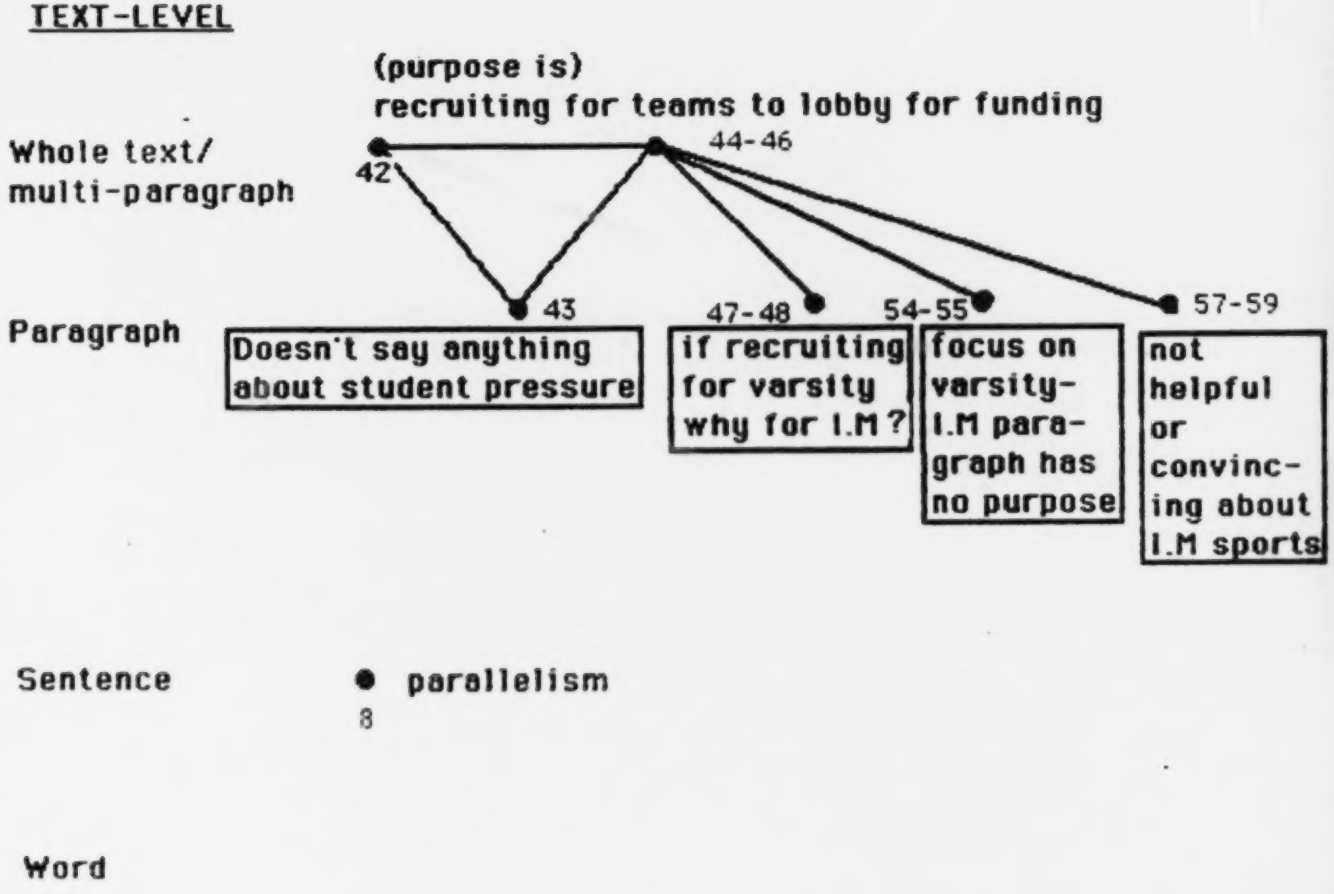

Figure 3. Expert's Diagnostic Comments

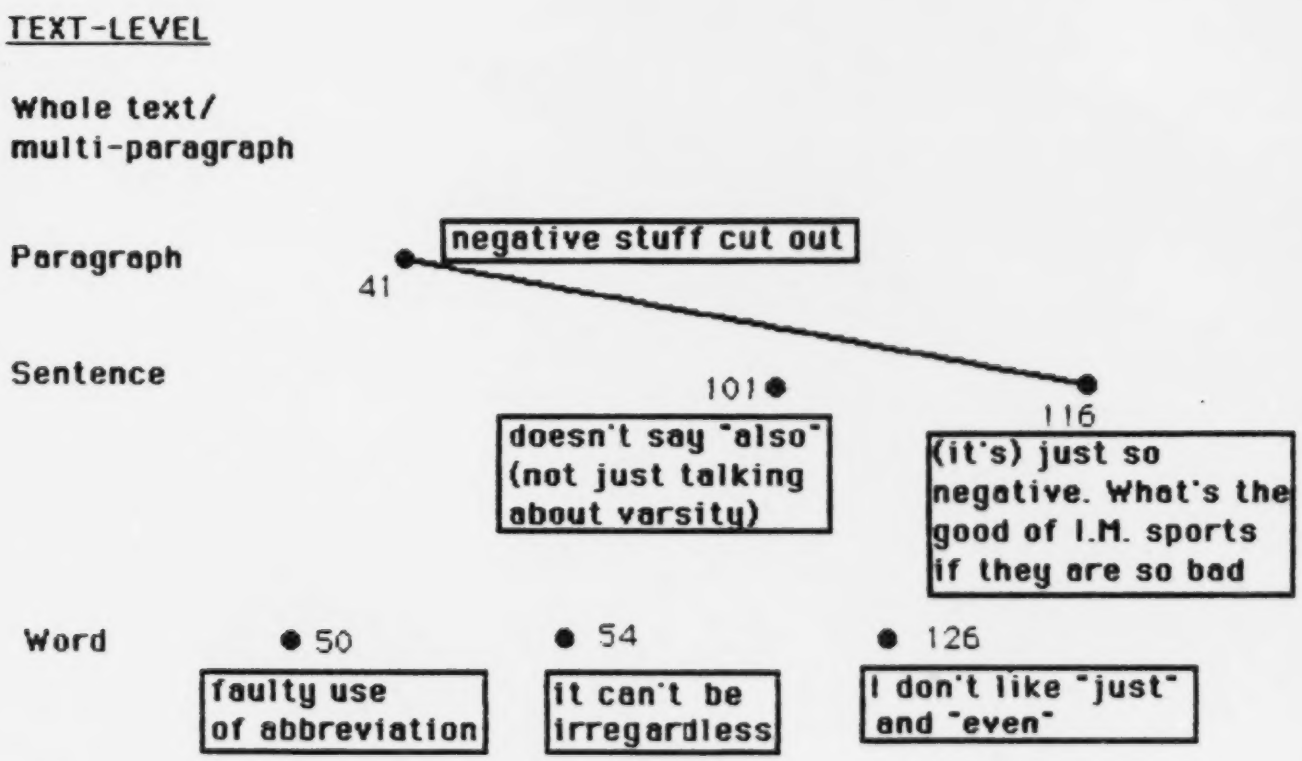

Figure 4. Novice's Diagnostic Comments

concept of the overall purpose of the memo (to recruit for teams in order to lobby for funding — P44-46) with paragraph level diagnoses which focus on:

- missing information (P43),
- illogicality in the argument structure (if the memo is recruiting for varsity teams, why talk about I.M. teams (P47-48)
- unhelpful and unconvincing information about I.M. sports which has no purpose (P54-55,57,59)

She successfully diagnoses some of the individual local problems within this paragraph; however, these diagnoses are closely related both to each other and to a larger whole-text problem. By creating this hierarchically structured and integrated representation, BA is able to work at several text levels simultaneously. She can thus "re-see" the text by working on local examples which contribute to the larger problem.

In contrast, novice subject, ML, (Figure 4) does not relate this paragraph to the text as a whole in her diagnoses. Rather than seeing one large problem, ML sees several small word-level problems (faulty use of an abbreviation —P50, and faulty word choice — P54,C126) which are not related either to each other or to the sentence level problems of incoherence (C101) or "negativeness" (C116) which she diagnoses. However, we do see this novice beginning to work more like the expert, though still on a paragraph, rather than a whole text level; she attempts to integrate a rather fuzzy paragraph-level diagnosis that this paragraph contains "negative stuff" (P41) with her diagnosis that a particular sentence seems illogical ("what is the good of I.M. if they're so bad" —C116)

These examples of a teaching expert and a student novice illustrate interesting differences which we noticed consistently between our subject groups. In Figure 5, we represent schematically the text levels and the amount of integration of the diagnostic comments of two other teaching experts and two other novices; all four of these subjects operated with a diagnose/revise strategy, but as the charts indicate, the experts' problem representations for this segment of the text are very different:

1. Experts' diagnoses were integrated into a hierarchical representation; novices were more fragmented and independent of each other
2. Experts diagnosed problems at several levels of the text with a substantial number of statements above the sentence level; novices were mainly concerned with sentence and word-level problems.
3. Experts predominately used intentional diagnoses to deal with global

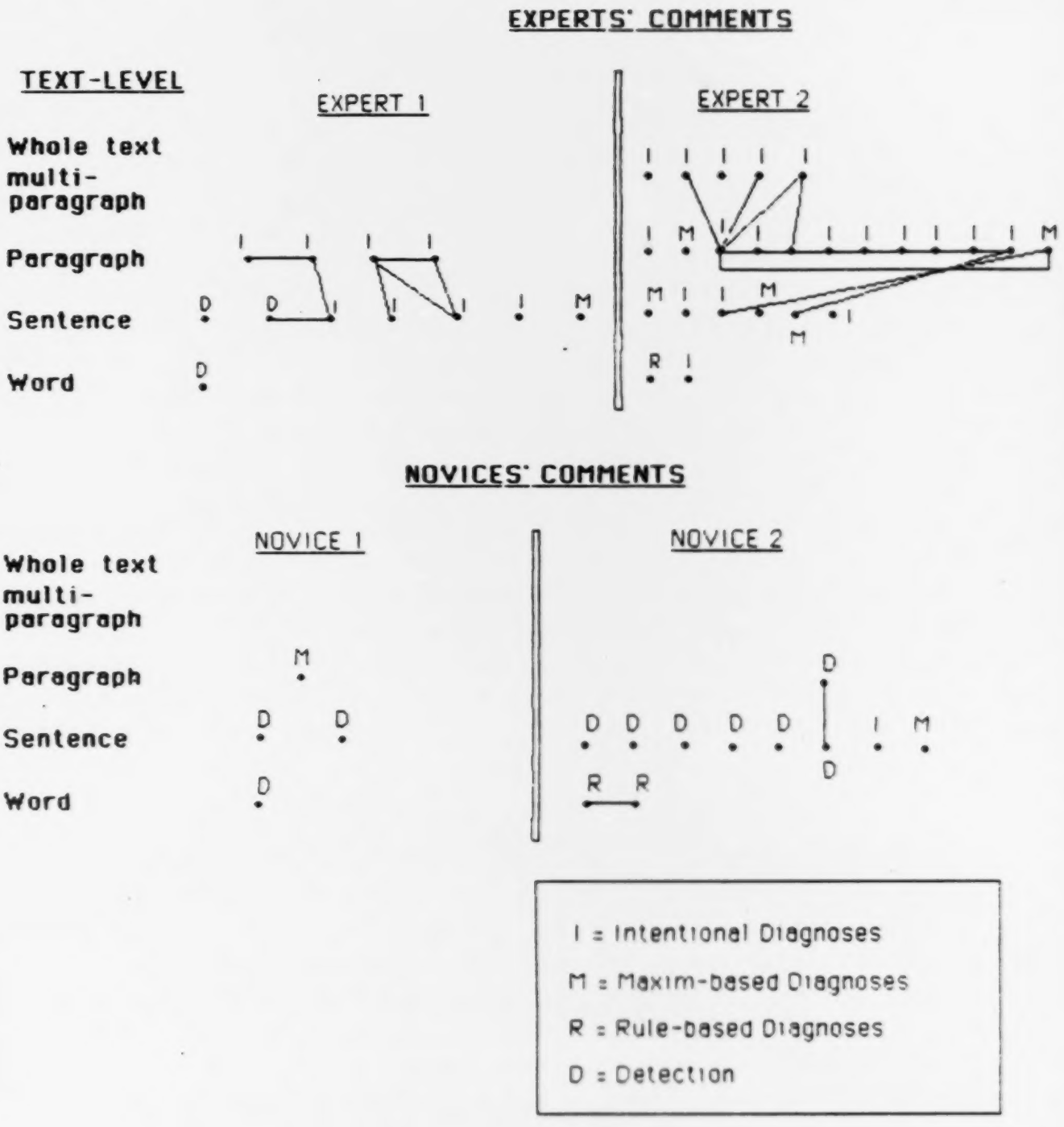

Figure 5. Networks of Experts' and Novices' Diagnostic Comments

problems (such as audience, purpose, coherence) above the sentence level; novices, when they attempted to diagnose problems with text units larger than a single sentence, tended to use:

- maxims which provided them with a more well-structured representation of the problem but which often over-simplified global problems. For example, one novice used a maxim—avoid wordiness—in an attempt to diagnose coherence problems with the whole paragraph.

- "simple detections", rather than diagnoses (see Figure 2), which gave them only a very vague sense that something might be wrong with the whole paragraph. For example, one novice commented that the whole paragraph "sounded ridiculous" and that it led her "in different directions"

Our analysis suggests that an expert's ability to integrate diagnoses of local problems with each other and with whole-text diagnoses allows her to operate both *bottom-up* and *top-down* in building a representation of complex problems; the expert is driven by the local problems in the text itself, yet she also *infers* the overall purpose of the text which guides her diagnoses of these local problems. This interaction of the local and the global thus provides the expert with a rich conceptual framework upon which to base her solution procedures. A novice, on the other hand, appears to be driven mainly by the text itself. This bottom-up procedure does not allow her to import a representation of the unstated purpose of the whole text. Because she *only* sees the isolated local problems, her solutions are more *ad hoc* and less goal-driven than the expert's.

In the next subsection, we will present case-study profiles which provide a more in-depth look at how two of our subjects, an expert and a novice, built representations of problems in our excerpted paragraph. In particular, we will look at how expert representations allow for more concrete solution procedures not available to novices.

Building a Representation of complex problems: Two case studies

Profile: Expert

Below, are six episodes taken from the protocol and cued-recall of an expert teacher who chose to diagnose problems and revise the text, rather than to re-write. We selected episodes which showed how the subject dealt with one of the major problems in the "I don't want to infer" paragraph, a problem which he categorized as "negativeness". Notice how he starts by working with whole paragraph as a single movable unit.

Protocol

P73 What I guess I'd do now is to move this paragraph, or the contents of it
P74 the one about personal benefits, up here
P75 Continue with the positive things about it rather than the negative.
P76 So I'm going to skip the paragraph talking about reluctance of time
P77 I'm going to go down and revise the paragraph that's talking about the benefits.
P78 Since I've just said benefits -- enjoyable and valuable.

.
.

C147 the whole sentence is just so wordy
I don't want to infer that the only chance women get for participating in sports is on varsity teams
C148 And it seems to me one simply emphasises the positive instead of the negative.

.
.

C163 If you look at these two sentences of which I guess I actually cut everything but about three words
C164 They are both split in the negative
C165 I don't want (to infer)
C166 Intramural sports are not —which I think is not the way a recruiting document should be.
C167 I think you should put in a positive statement.
C168 And secondly, both of them are really lead-ins that don't get you anywhere

.

C174 But since we use in addition to varsity sports...intramural sports attract these acts and so on
C175 where you tell what it is rather than what it is not.
C176 which is just a delaying tactic

.

C178 . My guess here is that

.

C181 (the writer) did not really know what she wanted to say.
C182 She was working toward what she wanted to say
C183 and she has two or three sentences almost all the way through
C184 two or three sentences to get to the point she really wants to make.

.

C188 The paragraph is claiming from the very beginning that she is going to talk about intramural sports,
C189 yet as I said, the first two sentences introduce intra-mural sports with a negative
C190 and then there's all this information about varsity sports.
C191 So what I tried to do was to substitute information about intra-mural sports.

.

C225 One of the other things this writer does, and I doubt the writer knows it.
C226 I'll go back to the previous paragraph
C227 I don't want to infer — intramural sports are not — influential aspects — in their reluctance It is like some of Melville's writing
C228 where either the words or the structure itself, connotation of the words or the structure itself is negative.
C229 It's negative, negative, negative.
C230 I don't have a logical mind
C231 I cant follow negatives
C232 I go make them over.
C233 And if I say that I do not want you to think that I don't care about your reluctance, I've lost myself,
C234 because I'm talking about a double negative about a negative mental attitude,
C235 and I cant follow it.
C236 I don't think most people can.
C237 I just changed the structure.

C240 I'm simplifying the sentence structure and making it more direct.

C261 That negative approach thing (feel that participating in sports is another pressure they don't need)
C262 They don't need it
C263 But its also that I just changed the whole sentence structure.
C264 The sentence structure as the writer had it is that many new students feel that participating in sports is another pressure they don't need.

C266 I set up the structure differently.

C441 Then it seemed to me to emphasize the benefits first as opposed to the reluctance or the problems students feel,
C442 so I brought the — so I changed the order from —
C443 the way this writer had it was the negative to the positive.
C444 I brought the positive to the benefits, to the negative,
C445 which I close with another positive statement to de-emphasize the negatives or the complaints of the problems people feel.

We found that this expert built a truly complex problem representation which was both elaborated and integrated; he saw many inter-related facets to the problems which provided him with a rich knowledge base for solving them. We also found that the expert was able to effectively locate problems in specific text features; this rather difficult "mapping" of general and abstract problems on to the text enabled him to draw on concrete procedures for solving the text problems. Let's take a closer look at these three features of his problem representation.

1. **Elaboration:** The expert's multi-facet diagnosis sees the "negativeness" problem not only in the words, but also in the syntax, in the ordering of information, and in the rhetorical effect of the text. For example:

    - The connotations of the words and the grammatical structure are both negative. (C228)

    - The "lead-ins" which lead nowhere (C168) highlight inappropriate and negative information. The sentences shift the focus to the worst aspects of sports and delay the presentation the key ideas.(C174-176)

    - A negative approach is inappropriate for the genre (a recruiting document). (C166)

    - The negative approach fails to realize the writer's intentions. (In effect, the diagnoser infers the intentions, decides the writer did not know what she wanted to say, and imagines possible reasons for this.) (C181-184)

    He also elaborates his representation by placing the problems in a broader context. For example, he recognizes recurring patterns of negative structure and tone throughout the whole text (P73-78); he generalizes about the rhetorical effect of "negativeness" — i.e. that "double negatives about a negative mental attitude" are too difficult for most readers to follow (C234-236); he compares the writing to Melville's (C227).

2. **Integration:** The expert integrates the different facets of his diagnoses at different text levels, building a coherent picture of the whole problem. Some cases in point:

    - He connects connotational problems with structural problems (234) and with faulty logic (C230-C237).

    - He sees a negative approach which is irrelevant to the audience (C261, 262) reflected in negative grammatical structure (C264)

    - He attributes the unfocused nature of the paragraph to negative information (C181-C184)

3. **Locating problems in the text:** The expert locates his diagnoses of "negativeness" in particular text features at several levels — multi-paragraph (P73-78), paragraph (C188-191), and sentence level (C261). Locating these large problems in the language of the text appears to be an important step in moving from diagnosis to action. As we found in our earlier examination of maxims, (see Section II), experts' problem representations seem to include more specific procedures than novices'. Certainly, this expert is able to come up with a range of procedures which are closely tied to text features:

    - move the paragraph to continue with the postive statements (P73-78) — multi-paragraph level.

    - put in a positive statement (C167) — paragraph level

- substitute information (in the paragraph) about intra-mural sports (C191) — paragraph level
- change the order of the statements from negative/positive to positive/negative/positive (C441-445) — paragraph level
- simplify the sentence structure to make it more direct (C240) — sentence level

Profile: Novice

The elaboration, integration and locating of problems in the text, which we noted in the expert's diagnoses, provide a contrast to the performance of one of the better and most fluent of the novices. The comments, below, represent this subject's diagnosis of this same problem paragraph.

Protocol

P41 I don't want...This is all negative stuff.
in which the rules are better, the equipment is better
P42 It can all be cut.
.
P45 They (are) a little more casual I guess.
P47 Um this I.M. down here, I'll go back to that too.
P48 I'll make basic corrections
P49 and then go back and improve.
P50 This I.M. There's no I.M. before
P51 so you have to go back
P52 so this should be Intra-mural again.
P54 Irregardless....it can't be irregardless.
P55 I guess I've got to change that.
P56 So we'll cut that out
P57 and it should be "I.M. sports...
P58 They can be just as much fun as varsity sports and take
less time."
.
.
P128 I don't want to infer...keep varsity,
P129 "intramural sports are...tend to be a bit more casual
and less demanding.
P129a I.M. sports may be..perhaps a more influential..
P130 Participating is an extra, um let me see..
P132 is an addition"
P133 Oh well, I'll go back to that.
.
.
P179 I don't want to infer that the only chance women get for
participating in sports is on varsity teams. "There is also
...there are also I.M. sports
P180 which are not quite the same as varsity.
P181 They tend to be a bit more casual"
.
.
C114 (Experimenter: you crossed out the whole..)
C115 Well it's just so negative.
C116 It's like, so what's the good of I.M. sports

C117 if there so bad.
C118 They're just a bit more casual, not as disciplined.
.
.
C125 (Experimenter: and just?")
C126 I don't like "just" either.
C127 "Even", "just" and "like", I don't like.
(Had commented earlier: "I was always told in any composition class I had that "like" is just bad to use. So I always put "such as".)

Where the expert's comments show an elaborated representation of the text problems, the novice's comments are sparse and undeveloped. The expert saw an interplay of lexical, syntactic, semantic, genre-related and rhetorical problems; the novice sees only one — "negative stuff" (P41). Her diagnosis is based on a simulation of a reader's response (C116-C118), a form of diagnosis which normally provides only a very generalized, and open-ended definition of the problem. This subject's response is also typical of novice diagnoses in that it depends primarily on the reviser's social or topic knowledge, rather than on rhetorical knowledge; she imagines what someone might say about I.M. sports, and rewrites the content of the text to fit her own ideas (P45, C118)

This segment of the novice's protocol also shows us a typically local and piecemeal diagnosis, rather than the more integrated diagnosis that we saw in the expert's protocol. The novice's diagnosis of the "negativeness" problem is limited to one line in the text (P41); she does not relate this important problem to the three other problems she sees — an unclear abbreviation and a faulty use of "irregardless" and of "just". Rather, she treats these latter problems as rule-governed errors solved by the favorite novice strategy — delete (C126).

Broad, intentional diagnoses, of the sort both expert and novice were making, pose a built-in problem for the reviser who must map something like a general sense of "negativeness" or a lack of focus to specific features in the text. Generally speaking, the more global the diagnosis, the harder it is to exactly locate the problem in the text and the fewer procedures are available for acting on the diagnosis. Here, while the expert has several procedures operating on different text levels, the novice has few. In fact, she demonstrates a typical novice strategy: first she localizes the problem in a single offending clause (P41); then she solves the problem by deleting (P42), and by substituting her own new information (P45). She returns to this section of the text on two later passes and simply rewrites the sentence to fit her own ideas about intramural sports (P128-133; P178-180). In

addition, on some occasions where she is unable to map a general diagnosis to the text (P133), she finally decides to leave the problem alone. We suspect that novice revisers simply may not know how to locate the source of their own response as a reader in the text features that prompted that response.

Despite the limitations of this novice response, we can see skills developing here. The reviser is looking at sentence-focus in terms of rhetorical effect; she is imagining the logical implications of a statement (C116) and is, in effect, trying to revise the text a reader might construct, not just the words on the page. Finally she is managing her own process of revision (P48-P49), handling the "basic correction" and "improvement" in two separate passes. However, this study does not answer the question of whether the maturation of the strategies we see here would lead to expert diagnosis, or whether the expert process calls for a new set of skills and rhetorical knowledge that go beyond standard maxims (don't use "like"), and beyond common-sense diagnoses based on social and topic knowledge.

The problem representations the experienced writers built were, it seems, not just bigger but qualitatively different from the novices'. The experts were 1) diagnosing several dimensions to an apparently simple problem, 2) seeing individual problems as part of a conceptual whole, and 3) locating a given problem at various levels of the text. The question one must then ask is, how do writers translate the representation of a complex problem into actions?

IV. SOLVING ILL-DEFINED PROBLEMS

In this section we will look at how writers try to solve a special set of highly ill-defined, whole-text problems. In an earlier phase of this study (see Hayes, Flower, Schriver, Stratman and Carey, in press) we reported on how writers handled a set of 26 problems "planted" in the text, which ranged from spelling and wordiness to organization. These were controlled problems on which we could expect experts to agree. However, we had designed the task include as well another set of pervasive global problems, problems springing from the fact that the voice, genre, style, and organization of the original text were inappropriate for its new purpose. We wanted to see first, if individual writers would attend to these problems at all, and if so, how they would represent the problem, and then translate that diagnosis into action. The present analysis is based on how writers responded to this special group of

open-ended problems.

To begin with, our experts did not fit a single "expert' profile. Although most of the experts dealt with these "global" infelicities in some way, there was surprisingly little overlap in the specific problems they defined and solved, even though the number of difficulties they saw far exceeded our planned distortions. Furthermore, the "solutions" they created for their self-defined problems varied from crisp P-R handouts to serious, informative discussions about women in athletics. Their overall revision strategies also varied. Two of the experts and one novice chose to work primarily as **rewriters**, which meant they chose to save the propositional content or gist of the text, but not its wording. This strategy allows them to eliminate the need for extensive diagnosis and to rewrite the text in their own words as a more or less fresh composition. Another subject, a professional writer, worked primarily as a **deleter**, a strategy he probably found useful in his job doing publicity releases. This strategy preserves more of the original text than rewriting does, but less of the content—that is, it does not add words, but strips away problematic text (and a good deal of information) to produce a reduced version of the original. The deleter strategy is fast, efficient and, like the rewriter strategy, precludes the need to diagnose. The deleter looks for key phrases than can be connected and deletes the intervening material. The remaining experts worked as **revisers**, which meant that they tried to preserve both the original text, as far as possible, and its propositional content. This strategy is less straight forward and calls for more diagnosis and repair, but it is also the strategy one would expect from teachers working with students or anyone trying to preserve both the wording and the content of the original as far as possible. The strategy a person chose had a predictable, marked effect on their process and the text.

To sum up, the most striking feature of the expert performance on these whole-text problems was the wide variation in terms of the problems they defined, the solutions they created and the procedures they used to do so. Perhaps this is not surprising. If we look at these whole-text diagnoses from a cognitive point of view, we see that these writers were frequently working with a special class of problems we can think of as **ill-defined revision problems**. When people attempt to "re-see" a text, to do "whole text" revision, or to change the marco-structure, they must grapple with features of coherence, organization, focus, and tone that resist clear-cut definition.

Ill-defined revision problems have two important features: First, the problem itself is typically a *construct* the writer must build; that is, it usually involves relations

among parts of the task (e.g., relations between ideas, parts of the text, the text and its gist, the gist and one's goals, the reader and writer, and so on). Recognizing such relations often means keeping previous sentences, earlier sections, or initial intentions in mind in order to compare the two. When diagnosis is based on these mental constructs, the problems are rarely as self-evident as those based on comparing a visible unit of text to a well learned rule. The problems are, in a sense, created by the reviser and even experts are likely to differ.

Second, the *procedures* for solving ill-defined problem are even more uncertain. How does one go about "re-seeing" anything?" There are, for example, no algorithms for fixing a weak organization, in part because the solution has to take so many elements of the text into account. Figure 2 shows the strategies that are typically associated with the three kinds of diagnosis we observed. Diagnoses based on Rules bring a set of relatively straightforward fix-it procedures. If you can diagnose the problem, you usually know what to do with it or where to find the information (e.g., check a handbook or the dictionary). Diagnoses based on Maxims rarely offer rule-governed procedures; the writer must begin to depend on heuristics or rules of thumb. And as we saw in section II, the procedural knowledge attached to even standard maxims varies widely. However, the strength of maxims rests on the fact that they can be translated into manageable strategies even novices can use. Intentional diagnoses are a different matter. For example, diagnoses which simulate a reader's response create highly ill-defined problems—what are you to do with the fact that "nobody will understand this"? Even diagnoses with more information about the problem (e.g., "the topic here keeps shifting from X to Y), tend to suggest rather complex heuristics that call for a good deal of judgment. More importantly, intentional diagnoses frequently lead the writer out of the revision process itself and back into planning. The appropriate procedure is often the most ill-specified, either because the writer must consider a number of possible heuristics (there is no standard method for creating "focus") or move up to planning itself.

Ironically, it might seem that the presence of ill-defined, less technical problems would have a leveling effect on differences in performance. Since there are no clear procedures available to either experts or novices, both are pushed to rely on more general problem-solving procedures. Revision is turned into a more open-ended thinking problem for which no one has pre-packaged answers. Nevertheless, the differences in how experts and novices handled these problems is strikingly apparent when we look, as we did in section III, at the overall problem representations they

construct for a given problem and when we look, as we shall now, at the strategies they use to deal with it.

Novice Strategies for Ill-Defined Problems

Let us consider for a moment the task demands a reviser might face in trying to improve a feature at the whole-text level, such as organization. First the writer must represent a gist of the text to herself. This may involve rereading and actually creating a gist if the text is not hers or if it is no longer fresh, or if it is the kind of unfocused prose that often emerges in first drafts. The evidence suggests that many student writers may not create such gists before revising (Witte, 1983) and that they have difficulty doing so when asked (Brown, 1983). In addition the writer may need to have a representation of her goals or purpose or of the function of individual parts of the text. That is, she will need to see the overall rhetorical structure or genre pattern into which the individual pieces will fit. Then she will need to test the text against either the goals or gist. It is likely that if she is checking multiple units (ideas or paragraphs, or even problems) against these intentions she will also need to see them as a set and chunk ideas and paragraphs or consolidate problems into meaningful groups, e.g., "this whole sequence goes off on a tangent." Then, assuming she is able to diagnose why the draft seemed disorganized, she must give herself a revision procedure. In the absence of well-defined procedures, revisers often solve ill-defined problems by considering alternative strategies or by returning to planning itself. To a novice, all these sub-processes may add up to a formidable task.

This array of task demands appears to come in conflict with another equally important demand--the reviser's need to create a manageable problem. Revisers, especially novices, often have to make a trade-off between the breadth of the problem, as they represent it, and the procedures they can bring to bear. As the problems one perceives (or represents to oneself) grow more ill-defined, the procedures attached to a diagnosis are likely to be less explicit , changing from rules and maxims to merely probabilistic heuristics (e.g., from "eliminate wordiness" to "be persuasive"; cf. Section II). And the procedures for such problems are harder to use, requiring the writer to consider, chunk and juggle more elements of the text. Eventually, when there are no specific heuristics in a reviser's repertory for some unique problem, the only reasonable procedure is one of the most demanding ones, a return to planning. A truly useful diagnosis then can only go as far along the continuum from more simple, well-defined to more complex ill-defined problems as

one's available procedures allow. (See Figure 2.)

The writing experience of most student writers has probably supplied them with clear, operational procedures for only the relatively local problems of grammar, usage and style. When they try to grapple with ill-defined problems and larger units of text and intention, they find they have no certain procedures for solving the problem. As Scardamalia and Bereiter (1983) have observed, even young writers see problems far in excess of their ability to solve them. The need to translate a problem definition into procedures faces everyone. However, experts and novices appear to meet this demand in different ways. The goal of the novices can be characterized as attempting to create a simply a manageable problem but an immediately manageable one. As they showed us, one can do this in a number of ways:

1. Recognize that an ill-defined problem exists, then turn to the Rewrite strategy and try to paraphrase or write a whole new version, saying it differently, and see if this version passes evaluation (Hayes, Flower, Schriver, Stratman and Carey, in press). Rewrite is the dominant novice strategy for good reason. The production skills of inexperienced writers are likely to be more developed then their diagnostic and strategic skills. Nevertheless it can be inefficient and, because it is uninformed by a clear sense of the problem, can miss the mark and produce text that is different but not better (cf. Bracewell, 1979).

2. Recognize that an ill-defined problem exists (e.g., "these ideas just don't go together"), but ignore it. The knowledge of social interaction, upon which novices often draw, may have little to say about fixing textual problems, and the discourse strategies which work in conversation, such as simple repetition, aren't considered an adequate way to build coherence in text. In want of a workable revision procedure, one simply moves on.

3. Recognize that an ill-defined problem exists and eliminate it simply by deleting the offending text. For instance, if a passage seems confusing or if an instructor sees a problem in the draft, it may be simpler to delete rather than to fix. This appears to be a major novice strategy.

4. Ignore ill-defined problems altogether and concentrate on problems which you can define or for which you have procedures . The tendency of students to focus on rule-governed, local problems and avoid meaning level changes is well

documented. We observed three strategies which might produce these results by reducing problems to a more manageable size. One is to narrow the meaning of maxims so that only a few constraints in the problem are actively considered (e.g., "avoid wordiness" is translated into "cut out adjectives") . A second is to treat conditional maxims as rigid rules—the same strategy Rose (1980) observed operating in invention. Conditional advice such as "don't use like in place of as," is simplified to "never use like." A third strategy simply narrows the target to a single word even though the problem the writer observes has a much broader scope. Instead of defining the problem as a "sexist letter," the writer concentrates her attention on a single offending word. Here is an extended example:

> Wait! This sounds really bad. "A further dividend..." That sounds like some kind of banking instructions or something. And "being part of any team allows the chance for very fine friendships to—" No, no!... "Very" I don't like. . . This "very fine" is pretty pushy.

Two of the novices in this study relied heavily on this strategy. Although both made a large number of Intentional diagnoses compared to other subjects (38 and 16), 50% and 31% respectively of these comments were focused on single words or phrases. As in the example above, the writer's insight, inferences, and diagnostic effort are appropriate for ill-defined, audience related problems, yet they are likely to have a limited pay-off since the target of all that energy is a single offending word or phrase.

In general, the novices in this study seemed to handle the need for procedures by reducing the task we gave them to a set of manageable problems. That is, except for periods of generate and test in Rewriting, they did not struggle with problems they did not know how to attack.

Taking Action on Ill-Defined Problems

Calling a problem ill-defined is a relative judgment. The problem that looks like a black hole to a novice might call up a standard procedure for an expert. In order to see how experts dealt with genuinely ill-defined problems, we looked for every instance in which a writer identified any of the whole-text problems of tone, audience, purpose, and genre which were created by the experimental task. These global or "whole-text " diagnoses were defined operationally as any diagnostic comment which clearly involved two or more sentences in the experimental text or which specifically identified a feature of the text as part of a recurring problem. We then looked at all actions of any sort attached to this diagnosis. Did the experts

simply know how to solve these problems?

As Table 1 shows, the frequency with which the experts even diagnosed such problems is much greater than the novices' by an average of 10.4 problems to 3. (The inter-rater reliability coding whole-text problems was 96.4). Any given Problem (i.e., problem cluster, such as the "negativeness problem" in the protocol quoted above) was likely to elicit a body of comments, which are averaged in the right hand column. (These averages are of course less meaningful in those cases where the writer saw only a few problems.)

Subject	# of Independent Problems Diagnosed	Total # of Comments *	Average # of Comments per Problem
Experts			
JP	20	161	8.05
BA	18	124	6.80
DS	10	69	6.90
SE	9	64	7.11
HL	5	26	5.20
HD	9	106	11.80
DE	2	17	8.50
Average	10.4		
Novices			
CC	6	37	6.20
JJ	1	16	16.00
ML	6	33	5.50
GB	3	34	11.33
MM	2	4	2.00
KC	2	4	2.00
NG	1	4	4.00
Average	3		

* Expert/Novice Differences
Sig. at .01 by Mann-Whitney

Table 1: Global Problems
The Number Diagnosed And the Extent to Which They Are Considered

In general, the experts are not only recognizing significantly more whole-text problems, they are spending a great deal of time and effort thinking about them--not what we might expect from an expert who already "knows how" to solve the problem.[2]

Herbert Simon's (1973) analysis of well-structured problems makes it clear why

these ill-structured or ill-defined problems can be so difficult to solve—even for experts. A problem is well-structured or ready-to-solve when the solver possesses the following information:

1. A clear set of goals that distinguish where you are now from where you want to be.

2. A set of operations or procedures that get you to the goal (with a practical amount of effort).

3. Clear criteria or tests for any proposed solution. That is, a way to know when you are closer and when you are done.

In even this relatively simple task, our subjects diagnosed many problems that had few or none of these features, problems such as: a horrible ending, parts that didn't connect, paragraphs with no purpose or an unclear focus, a sequence that was "neat" but didn't work logically, as well as more insidious faults of having a bad voice, being sexist, being unbelievable, and—the ultimate ill-defined problem— being boring. The question facing these diagnosers of ill-defined problems was one of managing complexity. To be more precise, how can you act in lieu of known or certain procedures? How can you make local changes that will somehow reach a global but underspacified goal (e.g., be interesting)? And how can you go about solving a problem which has no single answer and no sure or simple test for success? In the face of this situation, novices frequently lost their grasp on the hydra and ended up representing and solving only the immediately manageable problems with the strategies we discussed above. Experts on the other hand appeared to manage complexity by transforming ill-defined problems into actions they could take.

Table 2 categorizes the major actions experts took upon recognizing whole-text problems. The most frequent action was to generate sub-goals or sub-problems such as this response to the problem of a "negative beginning": "So a stronger opening might be something like—a—something like what? Something positive to say about the CMU women's teams." This response specifies two subgoals ("stronger opening" and "something positive") connected by the implicit ("like what?") goal of generating an example of something "stronger." In addition, these writers gave themselves process goals or instructions for how to manage their attention and how to proceed, as in , "I think I need to reread this" or the goal to generate an idea, mentioned above. (Because some comments contained both process and content goals, the total number of actions in Table 2 slightly exceeds the total number of responses.) A third and surprisingly small category of actions involved proposing actual text

changes. A fourth category, classified as Other, included a range of general problem-solving strategies, from drawing inferences and searching for information, to paraphrasing and monitoring the development of the text.

Subject	Total Actions	Sub-Goals	Process Goals	Text Changes	Other
Expert					
SE	50	26	11	6	7
DS	46	22	6	3	15
BA	78	17	17	10	34
JP	111	59	14	16	22
HL	17	11	1	2	3
HD	58	18	9	23	8
DE	7	2	0	5	0
Novice					
JJ	10	1	3	5	1
NG	2	1	0	1	0
CC	22	16	3	3	0
GB	28	13	3	8	4
KC	4	1	2	1	0
MM	2	1	0	1	0
ML	29	9	3	10	7

Table 2: Actions Following Whole-Text Diagnoses

A closer look at these expert actions suggests four strategies these experts used to manage ill-defined problems--strategies which brought them closer to the happy state of possessing a well-defined or well-structured problem.

1. In the act of building an Elaborated Problem Representation (discussed in Section III), the writers are also seeing this complex gestalt as a set of more familiar **sub-problems**, such as the problem of diction, of ordering ideas, and of fitting the genre, apparent in Figure 5 below. These are problems the writers more nearly know how to solve. And when these abstract problems are located in features of the text the diagnosis becomes more operational, because it now says something about where and how to proceed. It is the difference between being told to "be more clear" and being told to "define your two key terms earlier in the paragraph." Finally, once these abstract problems are given local habitation and a name in the form of sub-goals and text features, they can lead to text changes which, though the changes are themselves local, are controlled by a larger, integrated problem and plan.

2. As these writers explore the problem, they create sub-goals which are clear tests for success. These testable sub-goals let writers tell if their modifications actually solve the problem. Consider the difference between this novice's vague criterion, "Well, it's just so negative" and the tests implicit in the following expert comment: "It is like some of Melville's writing where either the connotation or the structure itself —connotation of the words or the structure itself is negative."

3. Creating clear tests and operational sub-goals could lead to solving a limited set of manageable sub-problems, but to a failure to encompass the gestalt one originally perceived, especially if its parts interact. For example, meeting the goal to introduce six new technical terms is likely to interact with one's attempt to maintain an informal and engaging style. One way experts keep this part/whole balance is by continuing to invoke global, holistic tests. For instance, this moment of truth comes near the end of a protocol after the writer had made a number of local revisions: "Read it over and see what it sounds like. I have a feeling that there is still a shift in tone. The first paragraph is more formal and it gets less formal as it goes along.." These global tests, that have both intentionality and scope, keep the expert honest and allow the problem-solver to shift back and forth from working on a manageable sub-problem to seeing its global effects. Experts too want manageable problems, but they are able to achieve this by treating sub-problems as parts of a larger whole.

4. The final and most significant expert strategy involves both goals, procedures and tests. It is the planning strategy in which revisers rise above the level of text to deal with the problem at a more abstract level. As Table 2 suggests, when experts proposed solutions it was rarely in the form of actual text, until the very end of an episode. They preferred to plan with goals and gists or paraphrases.

Figure 6 below offers a good illustration of the sequence and range of an expert's strategies. The initial segment of the protocol is quoted in full, followed by a schematic representation of the entire problem-solving episode in which the writer's comments are categorized as Actions and their Content is paraphrased.

Protocol Excerpt

My response to that marked off passage [marked off by the subject] is that it starts off very negatively at the beginning [Diagnosis]. It talks about -a- naive women and it talks about what they fail to realize [Diagnosis]. So a stronger opening [Action 1] might be something like -a-something like what? [Action 2]. Something positive to say about the CMU women's teams [Action 3] and the suggestion that even though they've done very well one shouldn't take that to mean that only people with long years of experience and practice need apply. [Action 4]. That in fact, a lot of the people who have been on winning CMU teams have not been recruited for those teams and have --what-- strays --have been walk-ons [Action 5]. Ok. So how do we do that? [Action 6].

Comment	Type of Action	Paraphrased Content
1	Set a sub-goal	Make a stronger opening
2	Set a process goal	Like what?
3	Set a sub-goal	Say something positive
4-5	Generate gists	Describe individual and team success
6	Set a process goal	How to do that?
7-10	Search the letter for supporting info.	
11	Set sub-goal	Assume "success" is true (Subject found no supporting info.)
12-23	Generate your own info.	
12	Generate trial text	
13	Evaluate	
14	Set sub-goal	Follow assertion with evidence
15	Set process goal	Indicate place for evidence with [] in margin
16-17	Set sub-goal	Consider various evidence
18	Generate trial sentence	
19	Set sub-goal	Use exclamation point?
20	Set process goal	Put ! in []
21	Set sub-goal	Use an example
22	Set process goal	Put example in a [] because it's made-up
23	Generate a gist	

Figure 6: The Sequence of an Expert's Planning Actions

The sequence of actions in Figure 6 shows both the persistence and the openness to possibilities which marks the way experts tackle ill-defined problems. It also shows how much of the problem is handled at the abstract level of goals and plans and gists , which are only finally (Comments 12 and 18) transformed into text. Even the absence of clear tests and crucial information fails to halt this expert. When his search of the text (Comments 7-10) reveals nothing to support his plan to talk about the team's success, he makes a temporary stay against uncertainty by simply imagining what he must, imagining the sort of information he needs, and setting process goals to check the bracketed text later. Working with goals and gists at this

level of abstraction is a planning strategy that allows one to integrate various goals at the top level before working out the details (Sacerdoti, 1974). It suppresses the local conflicts that inevitably occur when two goals are worked out in detail, such as trying to be technical and informal in the same sentence. These local problems then are confronted only after a tentative global plan is formulated. Because goals and gists are an efficient way to chunk lots of information, planners can easily consider alternative global plans, as do these experts. On the other hand, as they move down to more concrete representations of their solution, local constraints or conflicts can veto a solution that looked good in the abstract. This sends the writers back to planning and the search for a new plan that could resolve the dilemma.

Planning with goals and gists is a powerful strategy for dealing with ill-defined problems. In lieu of clear tests or procedures it lets writers start with their goals and plan their way into possible actions. Goals and gists give more flexibility than prose—they are easier to change than a string of words—and they put problems of large scope in a manageable compass.

The Path from Novice to Expert

The protocols show two paths that might lead our novices into expert performance. One strategy , which we saw developing in two novices, is to notice that certain problems are recurring in the text. At this point neither novice was able to exploit this knowledge and develop a coordinated plan—they dealt with each instance locally as a new problem (See Note 2). But if developed, this strategy might increase the scope of a novice's problem representation by letting the reviser add up instances into a composite diagnosis. A second strategy, used by a novice though aspiring professional writer, is to depend on one's genre knowledge (in this case one's knowledge of handouts) to guide rewriting in place of attempting diagnosis and revision. In this strategy she resembled some of the professional writers in our study (including one rewriter and a deleter) who did less over-all diagnosis than the instructors and who noticed fewer whole-text problems. Their solution to the experimental task was often based on their social knowledge of freshmen and genre knowledge of handouts—a fast and efficient procedure for a task one regularly handles.

Although these strategies show two reasonable lines of development novices might take, it is less clear that they are the most productive paths or ones that we should teach. Our analysis of the differences between expert and novice diagnosers suggests two other skills that might do more to capitalize on the novices' power for

intentional diagnosis while increasing the scope of their attention:

1. Teach students to "read" their texts as gists and to "read" for the goals behind a given piece of text. Learning to paraphrase the text and infer more global intentions, or to reconstruct one's own intentions, lets one approach revision as the task of changing goals and gists, not just words and sentences. It allows one to evaluate large parts of text as a single unit and to return to planning in search of new or more integrated solutions.

2. On the basis of this more global representation, help students learn to elaborate and decompose ill-defined problems into more familiar ones by the same general purpose problem-solving strategies that experts use: searching for information, generating sub-goals, hypotheses and possible solutions , looking for connections, locating the problem directly in the text, and re-representing the problem—in effect, hammering away at it.

We should never underestimate the importance of the expert's knowledge and experience—there are simply fewer ill-defined problems in the expert's world. However, it may be that a significant part of what makes experts succeed is their use of inference and paraphrase in "reading" the text, their willingness to turn to general problem-solving strategies when specific procedures are not available, and their persistence and perhaps confidence that such measures can work. It is possible that this strategic cognition, this combination of high-level goals and procedures, might come as a surprise to novices who define revision as the act of rewriting and the search for manageable problems.

Notes

1. This analysis is based on those experts who took the Diagnose/Revise paths and excludes those whose overall Rewriting or Deleting strategy would tend to eliminate the need to diagnose at all. Here coherence was operationally defined as any difficulty that explicitly involved a relationship between two or more parts of the text.

2. The Expert/Novice difference in the average number of Comments per problem was not significant ($p=.13$ by the Mann Whitney) due in part to the effect of Novice JJ (without her $p=.009$). But it is worth noting that her high score was based on repeated episodes of uncertainty over a single question (e.g., should she talk in the first should use "I" or "we")—quite unlike the profusion of ideas seen in the expert's mental debate in Figure 6. Although the data inconclusive, this pattern of extended, often exploratory commenting was a striking feature of most of the experts.

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